REMARKS

Claim Rejections - 35 USC § 112

The Examiner has rejected claims 18-20 and 23-25 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to point out and distinctly claim the subject matter which applicant regards as the invention.

In particular, the Examiner said that "it is confusing to state that the method is 'applying a prepulse' (as stated in claim 9) and 'applying a plurality of prepulses; (claim 18)." The Examiner stated further that "there is no support found in the specification for there being both a 'prepulse' and a 'plurality of prepulses' being applied 'prior to applying said programming pulse." The Examiner reiterated this rejection for claim 24. Applicants have amended claims 18 and 24 to overcome this rejection. This does not narrow the amended claims.

Claim 19 has been amended and rewritten in independent form. This renders Claim 19 allowable.

The Examiner has stated that there is no support in the specification for the language recited in lines 6-7 of claim 19. Applicants respectfully traverse this rejection. Lines 6-7 of claim 19 recite "wherein said first prepulse has approximately the same voltage with opposite polarity as said second prepulse." Applicants direct the Examiner to the following passage from the specification:

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> At step 302, **a full voltage, current limited prepulse** is generated across antifuse 100 to partially program antifuse 100. Thus, e.g., a high voltage is applied to top electrode 114 relative to bottom electrode 102 and the current is limited. In one embodiment, indicated by broken lines around step 303, a plurality of current limited pulses are generated, **e.g., a second full voltage, current limited pulse is generated with opposite polarity from the initial current limited pulse.**
>
> Specification, page 8, lines 28-33 (emphasis added)

Thus at least this part of the specification supports the referenced elements of claim 19. The specification also supports these claim elements in claim 25. Applicants request that the Examiner withdraw the rejections based on these elements.

With regard to claim 23, the specification discloses that "[I]f desired, another non-current limited fourth pulse 214 may be produced with an opposite polarity to the third pulse 212. Thus, the magnitude of the current of the fourth pulse 214 is I3, e.g., 12 mA to 17 mA, but is opposite in polarity of the current of the third pulse 212. The same voltage, e.g., 7.5V, is applied for each pulse as described above in reference to Fig. 2." Applicants assert that at least this passage, taken in conjunction with steps 304 and 306 of Figure 6, supports claim 23. Applicants respectfully request withdrawal of this rejection.

Claim Rejections - 35 USC § 102

The Examiner has rejected claims 1-3 and 5-25 under 35 U.S.C. 102(b) as being anticipated by Chan (U.S. Patent 5,243,226). Applicants respectfully request reconsideration of this rejection. *Chan* discloses an antifuse programming pulse scheme wherein the second pulse current is of lower magnitude than the first pulse current, the first pulse preceding the second pulse. See Figure 2. *Chan* discloses that "[t]he second pulse 210.2 reduces the antifuse resistance more consistently if current I2 is lower in magnitude than current I1." Col. 4, lns. 8-10.

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In accordance with this invention, a pulse that is current limited (low current) is applied to the antifuse prior to programming. This is also called a prepulse. This prepulse produces a conductive filament extending into the antifuse non-conductive layer. The conductive filament allows the subsequent higher current programming pulses to produce a better (lower resistance) current path through the programmable layer than does the prior art programming using only the programming pulses.

Nowhere does *Chan* teach or suggest

> "passing a current limited pulse through said material so as to drive material from said first conductive element into said material as a conductive filament; and
>
> passing a second pulse through said material in the opposite direction of said current limited pulse so as to drive material from said second conductive element into said material thereby increasing the cross sectional area of said conductive filament and reducing the resistance of said antifuse;
>
> **wherein the current in said current limited pulse is lower in magnitude than the current in said second pulse, and wherein said current limited pulse is passed through said material prior to any non-current limited pulse**,"

as recited in amended claim 1 (emphasis added). This method advantageously allows formation of the conductive filaments prior to application of the actual programming pulses. Applicants assert that claim 1 is thereby patentable over the cited reference and request withdrawal of the rejection of claim 1. Claims 2-3, and 5-8 are patentable at least for the reason of their dependence on claim 1.

Similarly, nowhere does *Chan* teach or suggest

> "applying a prepulse to said material, said prepulse having a current of a first magnitude that drives material from said first conductive element into said material as a conductive filament; and

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applying a programming pulse to said material, said programming pulse having a current of a second magnitude that drives material from said second conductive element into said material adding to said conductive filament;

wherein said current of a first magnitude is lower than said current of a second magnitude, **and wherein said prepulse is applied prior to applying any programming pulses,"**

as recited in amended claim 9 (emphasis added). Applicants assert that claim 9 is thereby patentable over the cited reference and request withdrawal of the rejection of claim 9. Claims 10-18 are patentable at least for the reason of their dependence on claim 9.

Chan also does not teach or suggest

"applying a first voltage across said material and a first current through said material, said first current driving a conductive filament with a first cross sectional area through said material; and

applying a second voltage across said material and a second current through said material, said second voltage having the same magnitude and opposite polarity as said first voltage, said second current having a greater magnitude and opposite polarity as said first current, said second current increasing the size of said conductive filament to a second cross sectional area, said second cross sectional area being greater than said first cross sectional area;

wherein said first current having insufficient magnitude to produce a conductive filament with said second cross sectional area**, and wherein said first current is applied through said material prior to any current which has sufficient magnitude to produce a conductive filament with said second cross sectional area**"

as recited in amended claim 21 (emphasis added). Applicants thereby request withdrawal of this rejection of claim 21.

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Similarly, *Chan* does not teach or suggest

applying at least one prepulse to said material, said prepulse including a first current to drive a conductive filament through said material, said first current having insufficient magnitude to produce said conductive filament with a desired resistance; and

applying at least one programming pulse to said material after the application of said at least one prepulse, said programming pulse including a second current having a greater magnitude than said first current to increase the cross sectional area of said conductive filament and to decrease the resistance of said conductive filament to a desired resistance,

wherein said prepulse is applied prior to the application of any programming pulses

as recited in amended claim 22 (emphasis added). Applicants assert claim 22 is patentable over the cited reference and request withdrawal of the rejection .

Allowable Subject Matter

The Examiner has stated that claim 4 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 4 has been amended to include such language. Applicants request allowance of claim 4.

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Summary

Applicants assert that all claims 1-25 are in a condition for allowance. Applicants request prompt allowance of all such claims. Should the Examiner have any questions regarding this response, the Examiner is urged to contact the undersigned (or Michael Guth) at (408) 453-9200.

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Respectfully submitted,

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Version with markings to show changes made

1. (Amended) A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said material being disposed between and in electrical contact with a first conductive element and a second conductive element, said method comprising:

passing a current limited pulse through said material so as to drive material from said first conductive element into said material as a conductive filament; and

passing a second pulse through said material in the opposite direction of said current limited pulse so as to drive material from said second conductive element into said material thereby increasing the cross sectional area of said conductive filament and reducing the resistance of said antifuse;

wherein the current in said current limited pulse is lower in magnitude than the current in said second pulse**, and wherein said current limited pulse is passed through said material prior to any non-current limited pulse.**

2. The method of Claim 1, wherein said current limited pulse and said second pulse have approximately the same voltage with opposite polarity.

3. The method of Claim 1, wherein said current in said current limited pulse is 20 to 33 percent lower in magnitude than said current in said second pulse.

4. (Amended) **[The method of Claim 1, further comprising:]** **A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said material being disposed between**

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and in electrical contact with a first conductive element and a second conductive element, said method comprising:

passing a current limited pulse through said material so as to drive material from said first conductive element into said material as a conductive filament; [and]

passing a second pulse through said material in the opposite direction of said current limited pulse so as to drive material from said second conductive element into said material thereby increasing the cross sectional area of said conductive filament and reducing the resistance of said antifuse; and

passing a third pulse through said material in the same direction as the current limited pulse, said third pulse being greater in magnitude than said current limited pulse, said third pulse further reducing the resistance of said antifuse**[.],**

wherein the current in said current limited pulse is lower in magnitude than the current in said second pulse, and wherein said current limited pulse is passed through said material prior to any non-current limited pulse.

5. The method of Claim 1,

wherein passing a current limited pulse through said material comprises applying a first voltage to said first conductive element and applying a second voltage to said second conductive element, said second voltage being greater in magnitude than said first voltage, and limiting the current to a desired magnitude; and

wherein passing a second pulse through said material comprises applying said second voltage to said first conductive element and applying said first voltage to said second conductive element.

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6. The method of Claim 1, wherein said material comprises amorphous silicon and said conductive filament comprises silicide.

7. (Amended) The method of Claim 1, further comprising passing a plurality of **[a]** current limited pulses through said material prior to passing said **[a]** second pulse through said material.

8. (Amended) The method of Claim 7, wherein passing a plurality of **[a]** current limited pulses through said material comprises passing at least two current limited pulses through said material, said at least two current limited pulses being opposite in polarity.

9. (Amended) A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said material being disposed between and in electrical contact with a first conductive element and a second conductive element, said method comprising:

applying a prepulse to said material, said prepulse having a current of a first magnitude that drives material from said first conductive element into said material as a conductive filament; and

applying a programming pulse to said material, said programming pulse having a current of a second magnitude that drives material from said second conductive element into said material adding to said conductive filament;

wherein said current of a first magnitude is lower than said current of a second magnitude**, and wherein said prepulse is applied prior to applying any programming pulses**.

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10. The method of Claim 9, wherein said current of a second magnitude is 20 to 33 percent greater in magnitude than said current of a first magnitude.

11. The method of Claim 9,

wherein said prepulse has a first voltage applied to said first conductive element and a second voltage applied to said second conductive element; and

wherein said first programming pulse has said second voltage applied to said first conductive element and said first voltage applied to said second conductive element.

12. The method of Claim 9, wherein said current of said programming pulse is applied in the opposite direction of said current of said prepulse.

13. The method of Claim 12, further comprising applying a second programming pulse to said material, said second programming pulse having a current of a third magnitude, said current of said second programming pulse being applied in the same direction said current of said prepulse.

14. The method of Claim 13, wherein said third magnitude is not greater than said second magnitude.

15. The method of Claim 13, wherein said third magnitude is greater than said second magnitude.

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16. The method of Claim 13, further comprising repeatedly applying said first programming pulse and said second programming pulse a predetermined number of times.

17. The method of Claim 13, further comprising repeatedly applying said first programming pulse and said second programming pulse until the resistance of said antifuse is below a predetermined value.

18. (Amended) The method of Claim 9, further comprising applying **at least one additional prepulse [a plurality of prepulses]** to said material prior to applying said programming pulse.

19. (Amended) **[The method of Claim 18, comprising:]** **A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said material being disposed between and in electrical contact with a first conductive element and a second conductive element, said method comprising:**

applying a prepulse to said material, said prepulse having a current of a first magnitude that drives material from said first conductive element into said material as a conductive filament; and

applying a second prepulse to said material after said applying a first prepulse to said material, wherein said second prepulse has said current of a **[first]** **third** magnitude;

applying a programming pulse to said material, said programming pulse having a current of a second magnitude that drives material from said second conductive element into said material adding to said conductive filament;

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wherein said current of a first magnitude is lower than said current of a second magnitude, and wherein said prepulse is applied prior to applying said programming pulses; and

[applying a first prepulse to said material, said first prepulse having a current of a third magnitude that is less than said second magnitude; and

applying a second prepulse to said material after said applying a first prepulse to said material, wherein said second prepulse has said current of a first magnitude;]

wherein said first prepulse has approximately the same voltage with opposite polarity as said second prepulse.

20. The method of Claim 19, wherein said third magnitude is approximately equal to or greater than said first magnitude.

21. (Amended) A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said method comprising:

applying a first voltage across said material and a first current through said material, said first current driving a conductive filament with a first cross sectional area through said material; and

applying a second voltage across said material and a second current through said material, said second voltage having the same magnitude and opposite polarity as said first voltage, said second current having a greater magnitude and opposite polarity as said first current, said second current increasing the size of said conductive filament

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to a second cross sectional area, said second cross sectional area being greater than said first cross sectional area;

wherein said first current having insufficient magnitude to produce a conductive filament with said second cross sectional area**, and wherein said first current is applied through said material prior to any current which has sufficient magnitude to produce a conductive filament with said second cross sectional area**.

22. (Amended) A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said method comprising:

applying at least one prepulse to said material, said prepulse including a first current to drive a conductive filament through said material, said first current having insufficient magnitude to produce said conductive filament with a desired resistance; and

applying at least one programming pulse to said material after the application of said at least one prepulse, said programming pulse including a second current having a greater magnitude than said first current to increase the cross sectional area of said conductive filament and to decrease the resistance of said conductive filament to a desired resistance,

wherein said prepulse is applied prior to the application of any programming pulses.

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23. The method of Claim 22, wherein said prepulse and said programming pulse have the same magnitude voltages with opposite polarities.

24. (Amended) The method of Claim 22, **further** comprising applying **at least one additional prepulse [a plurality of prepulses]** to said material.

25. The method of Claim 24, wherein said plurality of prepulses have approximately the same currents with opposite polarities.

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